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ABSTRACT

Due to massive widespread of COVID-19, complete lockdown was declared from late March-2020 by the Government of India. This lockdown led to considerable reduction in transportation, industrial activities and waste discharges. Noticing this reduction in production of pollution causing agents, a gradual improvement in environment was observed. Hence an observational study was done on the change in water quality in Rishikesh-Haridwar-Roorkee stretch of river Ganga in Uttarakhand due to lockdown. Parameters whose statistical values were observed included pH value, TDS (total dissolved solids), DO (dissolved oxygen), biological oxygen demand (BOD) and COD (chemical oxygen demand). These parameters were considered for the period from January 2018 to May 2021 and based on this study, improvement in water quality was observed. Among the three sites, the water quality at Rishikesh is the best at all times. The pH value is found to increase during lockdown and after lifting of lockdown in 2020. DO and pH are found to be positively correlated. To observe the effect of lockdown, the year 2020 has been divided into pre-lockdown (PL) period from January to March), during Lockdown (DL) period from April to August and Lockdown Open (LO) period from September to December. We observe that the pH value for Rishikesh, Haridwar and Roorkee are 7.71, 7.57, 7.63; 7.74, 7.8, 7.87 and 7.35, 7.69, 7.7 during PL, DL and LO respectively. Whenever the TDS (mg/L) concentration for Rishikesh, Haridwar and Roorkee are 75, 58.8, 93.25; 99.33, 81.2, 184.5 and 104, 85.8, 177 during PL, DL and LO respectively. Similarly, the DO (mg/L) concentration for Rishikesh, Haridwar and Roorkee are 11.16,10.4,10.85; 10, 9.7, 9.55 and 10.06, 9.12, 9.2 during PL, DL and LO respectively. Hence, almost the concentration of all parameters decreases during Lockdown included BOD (mg/L) and COD (mg/L). Hence, it was observed that all these parameters contribute differently to the quality of water, but on an average all of them remained within the permissible limits, and to some extend improved the water quality.

Keywords: *Uttarakhand environment protection and pollution control board, Lockdown, Water quality p arameters*

INTRODUCTION

COVID-19 has been the deadliest disease over decades, caused due to the virus SARS-CoV-2 and it's first outbreak occurred in Wuhan, Hubei, China around December 2019. First Covid-19 case in India was reported on January 30, 2020 from Kerala whereas in Uttarakhand, Covid-19 arrival was reported in Dehradun on March 15, 2020, after which rapid widespread of the disease occurred [1].

The virus was found to be spreading due to contact with infected person/thing and noticing the severity of the pandemic, total lockdown was declared on March 25, 2020. Henceforth, lockdown was lifted in stages according to the situation wherever the cases were less. Lockdown created procrastination for people, but it helped a lot in rejuvenation of nature. Visible improvements in nature like air quality, water, climatic behavior was observed reduction in air and water pollution due to transport and industrial sectors. Even the rarely seen migratory birds were spotted in few areas. The effects of COVID-19 on air quality have been reported by many scientists [2-6] for India and with special reference to Northern India [7, 8]. Similarly, the improvement on water quality has been found due to COVID-19 lockdown [9-14].

Keeping a note on this positive impact of lockdown, an observational study has been made on the effect of lockdown on water quality of India's most sacred river Ganges or Ganga. The Ganges or Ganga is the biggest river in the Indian subcontinent in terms of water flow [15] originating from the Garhwal Himalayas, Uttarakhand covering nearly 2,525 km journey ultimately drains into the Bay of Bengal. The life-giving river passes through Uttar Pradesh, Jharkhand, Bihar and West Bengal before meeting the sea in Bangladesh

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[https://www.tourmyindia.com/states/uttarakhand/ganga-river.html]

The present study is mainly focused on the water quality of the part of river Ganga in her originating North Indian state of Uttarakhand, with an area of 53,483 km^2, 86% of which is covered by Himalayan mountains including glaciers and 65% by forest. The five water quality parameters- pH, TDS (total dissolved solids), DO (dissolved oxygen), BOD (biological oxygen demand) and COD (chemical oxygen demand) for the river stream covering Rishikesh-Haridwar-Roorkee range. The values of various parameters have been compared for 3 years and 5 months (Jan 2018-May 2021) to note down the changes in these parameters from pre lockdown to during lockdown and then the post lockdown periods.

The paper is an analytical study of variations in parameters, which may help in concluding some important results regarding the quality of water

Review of Literature:

The effect on water quality parameters for different water bodies including rivers, lakes, ponds, canals, due to COVID-19 lockdown has been vastly reported for India [16-19]. The impact of lockdown on water quality of 19 major rivers in India was reported for pre lockdown period (March, 2020) and during lockdown (April, 2020) by Central Pollution control Board (CPCB), New Delhi, in association with State Pollution Control Boards and Pollution Control Committees (PCCs) under National Water Monitoring Program (NWMP) [16]. For the study, samples were collected from 4111 locations spread over 28 states and 8 Union Territories, with 2021 locations on rivers. The study showed improvement in the water quality for Brahmaputra and Yamuna in the north and Cavery, Krishna, Godavari and Tapi in the south whereas degradation in the water quality was found for Bias, Chambal, Ganga and Sutlej rivers. The overall assessment showed no significant improvement in the water quality.

Since the above study was done for a very short period of two months, it may not reflect clear picture. So, to get more reliable picture, we planned to conduct the study for longer period but restricting to a smaller region of river Ganga (from Rishikesh to Roorkee). This region is important in the sense that Rishikesh lies at the foothills of Himalaya where Ganga emerges from the mountains and starts its journey though plains. This region with industrial areas around can be responsible for pollution in the river.

Study Area:

For the present study, the Rishikesh-Haridwar-Roorkee stretch of the river Ganga is chosen to see the variation of five water quality parameters- pH, TDS, DO, BOD and COD in pre lockdown, during lockdown and post lockdown periods of COVID-19. The observations for these parameters have been considered at three sites: first at Laxman Jhula, Rishikesh; second at Har Ki Pauri, Haridwar and third at Ganga Canal, Roorkee. The Ganga canal (upper) is the original Ganges Canal built for irrigation purpose for Ganga- Yamuna doab region.

The First site is river Ganga at Laxman Jhula bridge, located 5 km north-east of Rishikesh at an elevation of 340m and coordinates 30.1264°N, 78.3299°E. Second site is the emerging point of upper Ganga Canal at Har Ki Pauri, Haridwar at elevation 314m asl and coordinates 29.9567°N and 78.1710°E and third site is Ganga canal at Roorkee, having coordinates 29.8543°N, 77.8880°E and altitude 268masl. (Fig. 1)

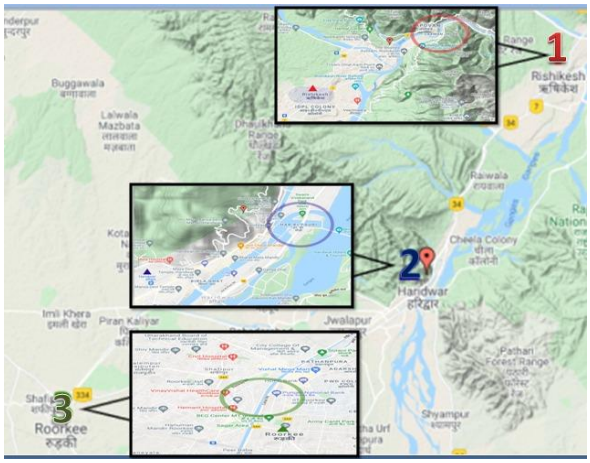

Fig. 1: Study Sites - Laxman Jhula, Rishikesh (Site1), Har Ki Pauri, Haridwar, (Site 2), Ganga Canal, Roorkee (Site 3)

METHODOLOGY

The data from Uttarakhand environment protection and pollution control board (UEPPCB) web portal [16] was collected for water quality parameters- pH, TDS, DO, BOD and COD for three and a half years beginning January 01, 2018. The main focus was to observe the effect on water of river Ganga in the Rishikesh-Haridwar-Roorkee stretch of Uttarakhand.

Standard values of parameters were taken from Google search [20,21]. For detailed description of each parameter, and cause of variation (increment or decrement), Google search was done.

The study has been carried out on the statistical data

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of water quality parameters of river Ganga for the period from January 2018 to June 2021, which has been collected from the official website of Uttarakhand environment protection and pollution control board [3]. For the comparative study, data of 3 sites, lying at different altitudes has been observed, Laxman Jhula, Rishikesh being at higher altitude (340 meters); Har ki Pauri, Haridwar in midway (314 meters) followed by Gang Canal in Roorkee at lower altitude (268 meters). Data is given in table 1, was analyzed and then comparison as made among the 5 water quality parameters and the yearly mean and standard deviation was calculated to conclude about the changes in water quality of River Ganga over the lockdown period.

RESULT AND DISCUSSION

The data collected for five water quality parameters- pH, TDS, DO, BOD and COD for the period from January 2018 to May 2021 at the three sites for river Ganga and are presented year wise in Tables 1 to 5. The year wise averages and standard deviations are also calculated for pH, TDS and DO.

These data are utilized (i) to study the seasonal variations of these parameters, (ii) The correlation between pH value and DO, TDS, (iii) to study the effect of lockdown due to COVID-19 pandemic.

A. Variation in pH values:

pH value of a solution determines the H^+ ion concentrations in the solution, which shows the acidic (pH < 7) or basic (pH > 7) nature of the solution. For the whole study period, at all the three locations, pH values indicate the alkaline nature of water except in March 2020 and February 2021 at Roorkee when pH was reported as 6.65 and 6.68. The values are well within the standard limits of 6.5-8.5 [22]. It is also evident that during rainy season, in general, pH decreases and has maximum values twice in a year, once after the rains and again in winter. The seasonal variation of pH has also been reported in literature [23].

Table 1: pH values of Ganga River at Rishikesh, Haridwar & Roorkee

Month	pH Rishikesh				pH Haridwar				pH Roorkee			
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**
Jan	7.38	8.02	7.72	7.61	7.89	7.92	7.7	7.3	7.93	8.12	7.8	7.85
Feb	7.82	7.42	7.72	7.28	8.14	7.68	8	7.66	7.87	7.82	7.6	6.82
March	7.32	7.48	7.7	7.81	7.8	7.56	7.54	8.33	7.69	7.54	6.65	8.2
April	7.48	7.62	7.8	7.26	7.56	7.54	7.6	7.36	7.64	7.45	7.4	7.5
May	7.5	7.54	7.1	7.6	7.62	7.62	8.03	8.22	7.81	7.8	7.95	7.55
June	7.42	7.62	7.55	-	7.94	8.4	7.9	-	8.04	7.87	7.8	-
July	7.45	7.7	7.92	-	7.42	8.1	7.3	-	7.71	7.9	7.65	-
Aug	7.56	7.48	7.5	-	8.04	7.7	7.95	-	NA	7.61	7.66	-
Sept	7.68	8.23	7.81	-	8.24	8.05	7.85	-	8.27	8.09	8	-
Oct	8.4	8.12	8	-	8.18	8	8.08	-	8.12	8.2	7.97	-
Nov	7.62	7.95	7.5	-	8.4	8.2	7.77	-	8.06	8.3	7.73	-
Dec	7.71	7.94	7.2	-	8.17	8.13	7.8	-	8.23	8.2	7.1	-
Average	**7.55**	**7.76**	**7.63**	**7.512**	**7.95**	**7.91**	**7.79**	**7.8**	**7.94**	**7.91**	**7.61**	**7.58**
Standard Deviation	0.245	0.351	0.425	0.143	0.291	0.291	0.262	0.205	0.209	0.133	0.315	0.427

Fig. 2 shows the variation of average pH values for the three sites for 2018, 2019, 2020 and 2021. To observe the effect of lockdown, the year 2020 has been divided into pre-lockdown (PL) period from January to March), during Lockdown (DL) period from April to August and Lockdown Open (LO) period from September to December. It shows that pH for Haridwar and Roorkee follow similar trend of increase and decrease with Roorkee showing larger variations. Mean pH first decreases from 2018 to 2020 (PL) period then increases up to 2020 (LO) period. The pH at Rishikesh, however, first increases from 2018 to 2019, then decreases till 2020 (DL) period and then follow the increasing trend in 2020 (LO). All the three sites show a decrease in pH value in 2021. Fig. 3 gives monthly pH variations at different sites for 2020 during PL, DL and LO periods.

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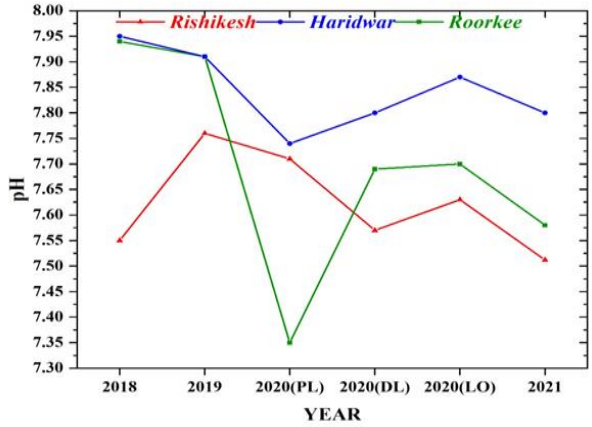

Fig. 2: Average pH variation at three sites

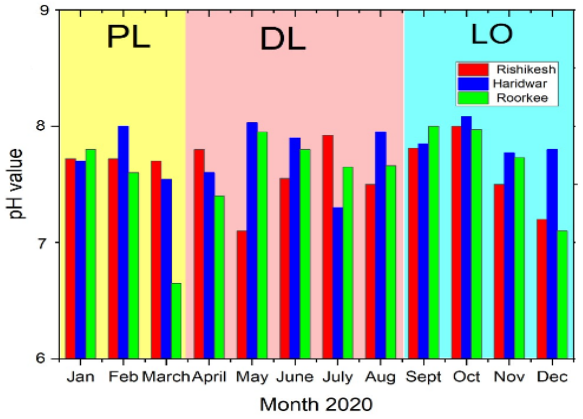

Fig. 3: Monthly pH variation in 2020

After the opening of lockdown from Sept-2020, pH values increased slightly to 7.63 in Rishikesh; 7.87 in Haridwar and 7.69 in Roorkee. Maximum alkalinity was observed in Haridwar due to reopening of industrial and tourist activities.

A. Total Dissolved Solids (TDS) in Ganges water:

TDS stands for total dissolved solids present in a solution. It indicates the amount of dissolved particles or solids present in water such as inorganic salts like chlorides, sulfates, bicarbonates of calcium, magnesium, etc., along with other inorganic compounds, easily dissolve in water [24, 25]. The monthly TDS values for the three sites of the present study are given in Table 2 for 3 years and 5 months of study period. The yearly averages and their standard deviations are also given. It is evident from the average values that the TDS values for Rishikesh are the minimum and that for Roorkee, the maximum.

Table 2: TDS values of Ganga River at Rishikesh, Haridwar & Roorkee

Month	TDS (mg/L) Rishikesh				TDS (mg/L) Haridwar				TDS (mg/L) Roorkee			
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**
Jan	92	114	79	112	112	98	122	126	104	105	108	152
Feb	105	96	62	76	121	126	71	59	105	120	91	76
Mar	96	86	84	70	109	100	105	95	104	116	113	108
Apr	87	88	55	70	100	96	63	79.2	108	112	78	103
May	82	80	51	97.3	88	88	80	111.2	98	110	73	104.5
Jun	84	82	64		86	85	92		90	99	95	
July	86	78	60		98	81	88		110	81	84	
Aug	80	80	64		106	83	83		NA	92	99	
Sep	74	73	101		106	78	162		113	86	174	
Oct	126	62	78		124	76	195		124	78	155	
Nov	80	69	80		126	105	257		117	108	230	
Dec	84	79	114		100	97	124		100	80	149	
Average	85.5	82.25	74.3	85.06	106.33	92.75	120.2	94.1	106.6	98.9	120.8	108.7
Standard Deviation	18.3	23.5	13.4	18.1	17.1	10.04	13.74	12.98	37.27	43.7	67.2	22.91

TDS of River Ganga in Uttarakhand have always been within the standard range 98.6-544.3, except for Rishikesh. In year 2018, Roorkee reported periods maximum average value of TDS of 106.64, and Rishikesh reported minimum TDS average 85.50. But, on the monthly basis, highest TDS value in 2018 was 126, in Rishikesh in the month of October. Average TDS in each year was maximum in Roorkee.

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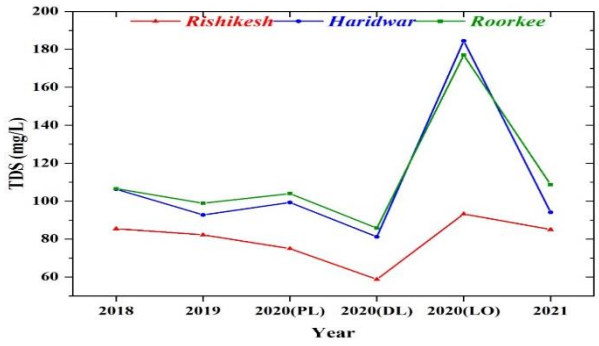

Fig. 4: Average TDS variation at three sites

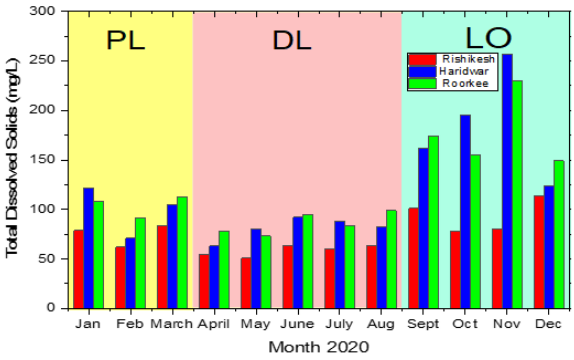

Fig. 5: Monthly TDS variation in 2020

Fig. 4 shows the variation of average TDS value for the three sites for 2018, 2019, 2020 (PL), 2020 (DL), 2020 (LO) and 2021. Haridwar and Roorkee show alternate increasing and decreasing trends whereas for Rishikesh, TDS is found to decrease upto 2020 (DL) period, followed by increase in 2020 (LO) and subsequent decrease in 2021. During lockdown period, reduction in TDS levels was observed at all the three cites, due to reduced waste discharge and pollution levels. But soon after the opening of lockdown, TDS levels again drastically increased to 257 and 230, for Haridwar and Roorkee, respectively, beyond safe limits of 50-100mg/L for drinking water. Monthly TDS variation for the year 2020 is presented in Fig. 5.

B. Dissolved Oxygen (DO):

DO is an important parameter of water quality that indicates whether a water body is the able to support aquatic life or not. DO is the amount of oxygen present in water bodies in dissolved form. Increase in DO levels is a good for water animals. In general, DO level below 3 mg/L can affect the health of aquatic animals. The low DO value may due to the large amount of organic matter in water body that is decomposed by microorganisms consuming the dissolved oxygen of water bodies. Table 3 presents DO values for the three study sites of river Ganga for the study period.

Table 3: Dissolved Oxygen (DO) values of River Ganga at Rishikesh, Haridwar & Roorkee

Month	**DO Rishikesh**				**DO Haridwar**				**DO Roorkee**			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Jan	9.8	10.4	11	11	9.4	9.6	10	9.6	9.4	9.2	10.4	9.6
Feb	10.2	10	10.8	9.8	9	9.8	10.2	9.2	9.2	9	9.8	10.2
March	10.4	9.8	11.6	10.4	9.8	9.6	9.8	9.4	9.4	9.2	10	9.8
April	9.8	9.8	10.6	10	9.6	9.4	10.2	9.6	9.6	9	9.4	8.4
May	10.2	10.2	11	10	9.4	9.2	9.8	9.4	9.4	9.4	9.6	9.2
June	9.8	9.8	10.6	NA	8.8	9	10	NA	9.2	9.2	9.6	NA
July	10	10.2	9.8	NA	9.4	9.8	8.8	NA	9	8.6	8.2	NA
Aug	9.8	10.4	10	NA	9	10	9.6	NA	NA	10	8.8	NA
Sept	9.8	9.8	10.8	NA	9	10.2	10.6	NA	8.2	10	9.6	NA
Oct	9.9	10	10.2	NA	9.2	9.2	8	NA	8.6	9.8	8	NA
Nov	9.6	11.8	11.6	NA	9	10	10.8	NA	8.4	9.4	9.4	NA
Dec	10	10.4	10.8	NA	10	10.2	8.8	NA	9	9.8	9.8	NA
Average	9.92	10.22	10.73	10.24	9.30	9.67	9.72	9.44	9.04	9.4	9.38	9.44
Standard Deviation	0.616	0.565	0.640	0.562	0.535	0.564	0.694	0.545	0.796	0.846	1.166	0.632

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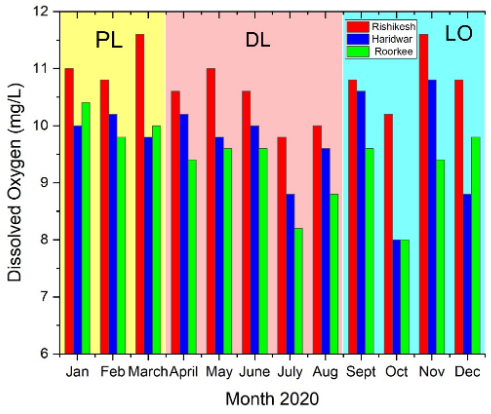

Fig. 6: Average DO variation at three sites

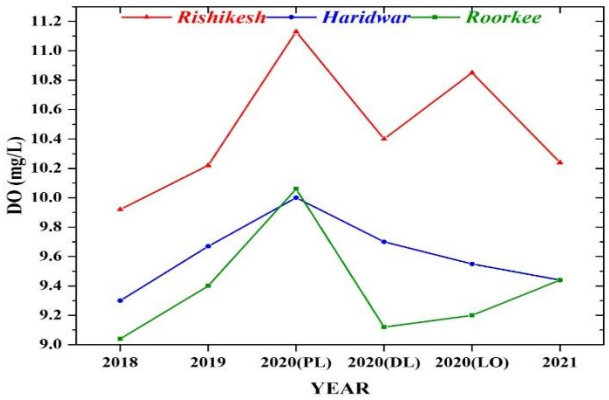

Fig. 7: Monthly DO variation in 2020

In fig. 6 average DO variation is plotted for 2018, 2019, 2020 (PL), 2020 (DL), 2020 (LO) and 2021 periods of the study. Increasing trend is exhibited for all the three sites up to 2020(PL) period followed by decreasing trend during lockdown period. For Roorkee, DO values show increase after the opening of lockdown. However, for Haridwar the DO values are found to be decreasing in 2020(LO) and continuing in 2021 as well and in Rishikesh, DO first increased during 2020 (LO) period then decreased in 2021. Fig.7 shows monthly variation of DO at all sites.

Lockdown has shown an opposite effect on DO levels, due to increase in domestic waste and sewage discharge into water bodies. which are due to the low temperature, as amount of dissolved oxygen in water is inversely proportional to the temperature of the respective environment.

In 2018, Rishikesh noted maximum average DO of 9.92, and Haridwar noted minimum average DO of 9.30. DO levels have always been greater than the standard DO values in Rishikesh, reason behind which is the cold environment of the place. Due to prolonged tourism at HAR KI PAURI, Haridwar, DO levels have always been high. Although, high level of DO is beneficial for aquatic life, if exceeds the healthy limits, can turns the water to corrosive in nature, and exceeded values may even affect aquatic life with “gas bubble disease”.

C. BOD (Biochemical Oxygen Demand):

BOD is the most widely used test for waste water which gives the concentration of organic matter in the water sample. The BOD test is also known as "BOD5" as the sample is placed in incubated conditions at 20°C for five-days to get the decrease in DO and that represents the "oxygen demand" for respiration by the biological microorganisms in the sample, the BOD. So, lower the BOD level better will be the water quality. Water with BOD <5mg/L is safe for drinking, according to WHO.

Table 4: BOD values (mg/L) for river Ganga in Rishikesh, Haridwar and Roorkee

Month	BOD Rishikesh				BOD Haridwar				BOD Roorkee			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Jan	<1	<1	<1	1	<1	<1	<1	1.2	1	1	1	1.4
Feb	<1	<1	<1	1	<1	<1	<1	1	1	1	1	1.4
March	<1	<1	<1	1	<1	<1	<1	1.2	1	1	1	1.2
April	<1	<1	<1	1	<1	<1	<1	1.2	1	1	1.2	1.4
May	<1	<1	<1	1	<1	<1	<1	1.2	1	1	1	1.2
June	<1	<1	<1	-	<1	<1	<1	-	<1	1	1	-
July	<1	<1	1	-	<1	<1	1.2	-	1	1.2	1.4	-
Aug	<1	<1	1	-	<1	<1	1.2	-	NA	1	1.6	-
Sept	<1	<1	1	-	<1	<1	1	-	1	1	1.4	-
Oct	<1	<1	1	-	<1	<1	1	-	1	1	1.2	-
Nov	<1	<1	1	-	<1	<1	1	-	1	1	1	-
Dec	<1	<1	1	-	<1	<1	1	-	1	1	1.2	-

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Table 4 depicts the BOD values for Ganga River for the three sites. It shows that for all the three locations the values are well within the prescribed limits with minimum at Rishikesh and maximum at Roorkee. The values are found to increase at all the locations when the lockdown was lifted in July 2020 possibly due to start of some industrial activity. BOD levels increase in 2021may be due to increased post lockdown activities, tourism, mass bathing during Kumbh Mela.

D. Chemical Oxygen Demand (COD):

The COD is the amount of oxygen required by the organic matter in waste water to fully oxidize into carbon dioxide and water. COD is a measure of the amount of total organic matter present in the water whether it is biologically active or biologically inactive. This is the main difference between BOD and COD tests. In a BOD test, only biologically reactive carbon is oxidized while in a COD test, all organic matter is converted to carbon dioxide. The COD values are, thus, higher than BOD. The other advantage of COD test is that it can be done in 3 hours against 5 days required for BOD5 test. The COD of surface water normally ranges from 5 to 20 mg/L.

Table 5 shows the COD values for water of Ganga River for the three sites. It shows that for all the three locations the values are well within the prescribed limits with averages 4.02, 4.24 and 5.2 for Rishikesh, Haridwar and Roorkee, respectively, for the whole study period. However, no significant effect of lockdown can be found in COD values.

Table 5: COD values (mg/L) of river Ganga in Rishikesh, Haridwar and Roorkee

Month	COD Rishikesh				COD Haridwar				COD Roorkee			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Jan	4	4	4	4	4	4	4	6	4	6	4	6
Feb	4	4	4	4	4	4	4	4	6	6	6	6
March	4	4	4	4	6	4	4	4	6	4	6	6
April	4	4	4	4	4	4	4	4	6	4	6	6
May	4	4	4	4	4	4	4	6	4	4	4	6
June	4	4	4	-	4	4	4	-	4	6	4	-
July	4	4	4	-	4	4	6	-	4	6	6	-
Aug	4	4	4	-	4	4	4	-	NA	4	6	-
Sept	4	4	4	-	4	4	4	-	4	4	6	-
Oct	4	4	4	-	4	4	4	-	6	4	6	-
Nov	4	4	5	-	4	4	4	-	6	4	6	-
Dec	4	4	4	-	4	4	6	-	6	4	6	-
Avg.	4	4	4.08	4	4.17	4	4.33	4.8	5.09	4.67	5.17	6

Increasing levels of COD in water is indicator for bad water quality. COD levels in Roorkee showed maximum value of 6 among all the 3 sites, soon after the lockdown opened from September 2020 due to rapid onset of industrial working. Increase in COD levels is continuously observed in Haridwar during lockdown, post lockdown up till the MAHAKUMBHA period, which indicates water quality got affected due to lockdown, and noted maximum average of 4.8mg/L during 2021, which is the post lockdown period.

Table 6 presents a summarized collective comparison of average values of all the parameters studied i.e., pH, TDS, DO, BOD and COD at all the three sites.

Table 6: Collective comparison of average values of parameters:

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Site	S.no.	Year	pH	TDS (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
	1	2018	7.55	85.5	9.92	<1	4
	2	2019	7.76	82.25	10.22	<1	4
	3	2020(PL)	7.71	75	11.13	<1	4
	4	2020(DL)	7.57	58.8	10.4	0.72	4
	5	2020(LO)	7.63	93.25	10.85	1	4.25
	6	2021	7.512	85.06	10.24	1	4
	S.no.	**Year**	**pH**	**TDS (mg/L)**	**DO (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**
	1	2018	7.95	106.33	9.3	<1	4
	2	2019	7.91	92.75	9.67	<1	4
	3	2020(PL)	7.74	99.33	10	<1	4
	4	2020(DL)	7.8	81.2	9.7	0.88	4.4
	5	2020(LO)	7.87	184.5	9.55	1	4.5
	6	2021	7.8	94.08	9.44	1.16	4.8
	S.no.	**Year**	**pH**	**TDS (mg/L)**	**DO (mg/L)**	**BOD**	**COD**
	1	2018	7.94	106.64	9.04	1	5.09
	2	2019	7.91	98.91	9.4	1.1	4.67
	3	2020(PL)	7.35	104	10.06	1	5.33
	4	2020(DL)	7.69	85.8	9.12	1.24	5.2
	5	2020(LO)	7.7	177	9.2	1.2	6
	6	2021	7.58	108.7	9.44	1.24	6

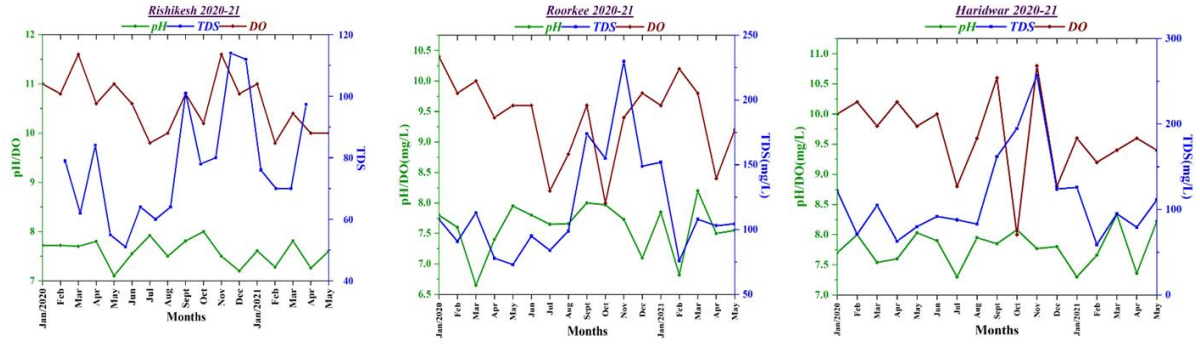

Fig. 8: Correlation between pH, DO and TDS for Rishikesh, Haridwar and Roorkee

In Fig. 8 TDS, DO and pH are plotted as a function of month for Rishikesh, Haridwar and Roorkee to find the correlation between these parameters. It is evident from these figures that a positive correlation exists between pH value and DO, whereas TDS and pH are negatively correlated. This has also reported in earlier studies also [26].

CONCLUSION

A positive impact of lockdown on water of river Ganga has been observed and nature has in all rejuvenated during the COVID-19 lockdown.

City wise comparison is done to observe the values of water quality parameters of river Ganga at different altitudes and the year wise comparison gives a detailed idea of effect of lockdown on the values of these parameters as compared to their values pre lockdown and post lockdown. Noticing the trend in variation of parameters pre, during and post lockdown; a subsequent improvement in quality of water has been observed.

Reduction in industrial waste discharge, tourism activities, bathing and cloth washing in river water has in all led to improvement in quality of water. The toxicity in the water was reduced to a good extend. Major impact was due to the cut-off of the industrial waste discharge into water bodies.

But, if we compare the data of 2018-2019, i.e just before the lockdown with the data of past years, water

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quality has deteriorated in the last decade, gives a bad remark on water management techniques. Though the lockdown has shown good improvements in nature, but still the values of parameters are visibly very high as compared to their values 3-4 years ago, which sets an alarming situation to keep a note on managing waste water and to maintain the improvement trend of water quality post lockdown as well as in the upcoming years. It will not only benefit nature, but also other living beings, as quality of water is also a part of our life cycles.

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